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ABSTRACT

Fourier analysis, a common technique in engineering, breaks down a complex wave form into its simple sine wave components. Communication researchers have recently suggested that this technique may provide an index of the rhythm of conversation, since vocalizing and pausing produce a complex wave form pattern of alternation between two speakers. To determine whether the suggestion has validity, Fourier analysis was used to characterize the rhythm of sound and silence in 2 markedly different sets of 24 conversations each. The first set ("low cognitive load" conversations) came from an earlier study in which previously unacquainted pairs spent 10 minutes talking about themselves. The second set ("high cognitive load" conversations) came from pairs of students asked to discuss a current events topic. Each subject was given 10 minutes to think about the issue before engaging in a 10 minute conversation with a same-sex partner. Voices of each subject were recorded and each conversation was converted into a curve by means of a microcomputer. Fourier analysis was able to group the flow of vocalizations and pauses into larger repetitive patterns and to distinguish between the two sets of conversations. There were more "megaturns," or slow moving cycles, indicating serious discussion, dominating the talking in the conversations dealing with the current events topic than in the getting-acquainted conversations. (FL)

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Fourier Analysis and the Rhythm of Conversation[1]

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Abstract

Fourier analysis may provide an index of the rhythm of conversation. Vocalizing and pausing produce a complex waveform pattern of alternation between two partners. Fourier analysis breaks this pattern down into its simple sine wave components and specifies how much variance is attributable to each component. Analysis of the stream of vocalizations and pauses in 48 10-minute conversations showed long cycles, or "megaturns," more characteristic of more serious discussions. Fourier analysis may be able to quantify the rhythmical nature of other kinds of social interaction.

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Fourier Analysis and the Rhythm of Conversation

There is a rhythm to conversation. Ideas flow, speakers take turns, and sound and silence alternate. Fluctuations in intensity, enthusiasm, humor, and other qualities are common. The pace becomes more or less spirited over time.

The rhythm is part of the background. It often passes unnoticed, as we focus upon the details of words and how they are uttered. This focus causes some problems in doing research. Analyzing words and their meaning is time-consuming, requiring hours of coding for each hour of conversation. Analyzing how words are uttered, with such variables as speech rate and pause length, does not do justice to the complexity of ordinary discourse. Changing our focus to examine instead the rhythm of conversation could provide a different perspective, removing the immediate detail and allowing us to see an underlying flow.

Rhythm is a basically regular recurrence of elements or features as they alternate with different or opposite elements or features. In conversation, these elements or features might include pause, accent, pitch, rhyme, emotional tone, specific words, formal or stock phrases, or nonverbal gestures and facial expressions. Their presence and absence produces an alternating pattern that is more or less complex.

Such a pattern can be analyzed using Fourier analysis, which breaks down a complex waveform into simple sine wave components. Somewhat like analysis of variance, it partitions the total variance of a waveform into portions attributable to different components. The technique is common in engineering, and recent papers suggest it might be useful for studying social behavior (Gottman and Ringland, 1981; Porges, Bohrer, Cheung, Drasgow, McCabe, and

Keren, 1980; Warner, 1979).

It is an open question as to how well the raw data of conversations meet the assumptions of Fourier analysis. Fourier analysis assumes stationarity, which means the basic nature of the curve is unchanging over time. The work of Jaffe and Feldstein (1970) suggests conversations have stationarity, though undoubtedly some do not. However, stationarity is crucial only if one plans to draw statistical inferences from the Fourier analysis itself. If one intends instead to produce index scores that will in turn be treated as other dependent variables are treated, the assumption of stationarity is less important. (See Bakeman & Dabbs, 1976, pp. 338-339, for a comparable use of inferential statistics as index scores.)

Method

The present study used Fourier analysis to characterize the rhythm of sound and silence in two markedly different sets of 24 conversations each. The first set ("low cognitive load" conversations) came from the study by Dabbs, Evans, Hopper, and Purvis (1980). Previously unacquainted pairs of college students spent 10 minutes talking about their backgrounds, activities in school, or things outside of school. Half the pairs were high in self monitoring and half were low (Snyder, 1974), but in the present analysis the self monitoring dimension was ignored. The second set ("high cognitive load" conversations) came from pairs of students asked to discuss the fuel crisis: how serious it was, whose fault it was, and what should be done about it. Each subject was given 10 minutes alone to think about the problem before beginning a 10 minute discussion. All conversations were among same-sex partners; half the pairs in each set were male, and half were female. Obviously "cognitive load" was only one of a number of differences among the conversations. The point of the present study, however, was less to examine

the nature of cognitive load than to see what differences in rhythm Fourier analysis could identify between two markedly different kinds of conversations.

Voices of the two subjects in each pair were recorded on separate audio channels, as described by Dabbs et al. (1980). (Eye contact was also recorded and analyzed but will not be discussed here.[2]) A microcomputer system sampled the on-off state of the speech channels every 250 msec and transferred this information to a larger computer, which computed for every 250 msec interval the Jaffe and Feldstein (1970) parameters of turn, vocalization, and pause. Each conversation was converted into a curve by scoring at each moment A's vocalizations as +1, B's vocalizations as -1, and pauses as zero. (Simultaneous speech, or speaking "out of turn," is ignored in this approach.) Figure 1 shows a resulting one minute sample of conversation. The solid waveform represents observed data. The dotted line represents an underlying sine wave component that might be extracted by Fourier analysis.

Insert Figure 1 about here

Fourier analysis was performed on the curve of vocalizing and pausing in each of the 48 conversations using the Fast Fourier Transform (FFT). The FFT is described by Brigham (1974); a computer program written by Mark Evans to handle the present data is available from the author. FFT requires as data input a time series with a number of points equal to a power of two. For each conversation, the first 2048 data points (512 seconds) were analyzed. With this input FFT computes the variance attributable to 1024 component frequencies, these frequencies ranging in equal steps from .002 Hz to 2 Hz (from one cycle to 1024 cycles per 512-second conversation). The results will

be presented here in terms of cycle length (the reciprocal of frequency), because many of us find it easier to think of cycle lengths than of frequencies; the cycles could vary in length from 512 seconds to .5 seconds. While the 1024 component frequencies are equally spaced, the corresponding cycle lengths become more similar as they become shorter. To reduce somewhat the bunching up among short cycle lengths, variance accounted for was summed for bands of equal numbers of cycle length values on either side of the 12 values shown on the ordinate in Figure 2. Thus the 1024 discrete cycle lengths were reduced to a total of 12 bands.

Results

Figure 2 summarizes the results for the 24 low and 24 high cognitive load conversations. The cyclical pace, or rhythm, differed between the two kinds of conversation. High load conversations had more variance in long cycles, in which one or the other partner did most of the talking, with the shift from one partner to the other and back occurring over a period of from 32 to 128 seconds. These long cycles might be called "megaturns;" they were presumably due to the extra thinking or some other experimental demand associated with discussing the fuel crisis. Low load conversations had more variance in cycles only 2 to 4 seconds long, slightly shorter than the length of an average turn (mean turn length was 4 seconds among these 24 conversations) and presumably reflecting the effect of individual pauses and frequent short statements and murmurs.

Insert Figure 2 about here

The FFT results summarized in Figure 2 were analyzed statistically using three-way analysis of variance, with conversation type and sex as between-pair

factors and the 11 cycle length bands as a within-pair trials factor. The dependent variable was the percent of variance attributable to each band of cycle lengths. The difference between the two curves in Figure 2 (the interaction of conversation type with cycle length) was highly significant, $F(10, 440) = 17.67$, $p < .001$.

Discussion

Fourier analysis allows one studying conversation to go beyond the sharply defined parameters of Jaffe and Feldstein (1970). It accepts any parameter that varies with time, then searches for orderly patterns of fluctuation. Here, Fourier analysis grouped the flow of vocalizations and pauses into larger repetitive patterns and distinguished between the two sets of conversations. There were more megaturns, or slow-moving cycles of dominating the talking, in discussing the fuel crisis than in getting acquainted. The significance of the megaturns is unclear; they are plausibly due to the cognitive load involved in discussing the fuel crisis, but they could also be due to subject selection or some other experimental confounding.

We do not know much about the importance of the cyclical quality of social interaction. This quality might be related to participants' responsiveness and feelings of satisfaction. Many social exchanges do have rhythm, and the rhythm varies depending upon whether one is consulting with a colleague, engaged in a shouting match, telling stories, or exchanging social pleasantries. Perhaps social rhythms have their basis in the physical activities of life in general (Ayres, 1973). Regardless of its origins, rhythm is a central aspect of social behavior. Social behavior cannot be captured with static parameters. It extends and cycles over time, and we need ways of studying this cyclical quality.

References

Ayres, B. Effects of infant carrying practices on rhythm in music. Ethos, 1973, 1, 387-404.

Bakeman, R. & Dabbs, J. M., Jr. Social interaction observed: Some approaches to the analysis of behavior streams. Personality and Social Psychology Bulletin, 1976, 2, 335-345.

Brigham, E. O. The fast fourier transform. Englewood Cliffs, N. J.: Prentice-Hall, 1974.

Dabbs, J. M., Jr., Evans, M. S., Hopper, C. H., & Purvis, J. A. Self-monitors in conversation: What do they monitor? Journal of Personality and Social Psychology, 1980, 39, 278-284.

Gottman, J. M., & Ringland, J. T. The analysis of dominance and bidirectionality in social development. Child Development, 1981, 52, 393-412.

Jaffe, J., & Feldstein, S. Rhythms of dialogue. New York: Academic Press, 1970.

Porges, S. W., Bohrer, R. E., Cheung, M. N., Drasgow, F., McCabe, P. M., & Keren, G. New time-series statistic for detecting rhythmic co-occurrence in the frequency domain: The weighted coherence and its application to psychophysiological research. Psychological Bulletin, 1980, 88, 580-587.

Snyder, M. The self-monitoring of expressive behavior. Journal of Personality and Social Psychology, 1974, 30, 526-537.

Warner, R. M. Periodic rhythms in conversational speech. Language and Speech, 1979, 22, 381-396.

Footnotes

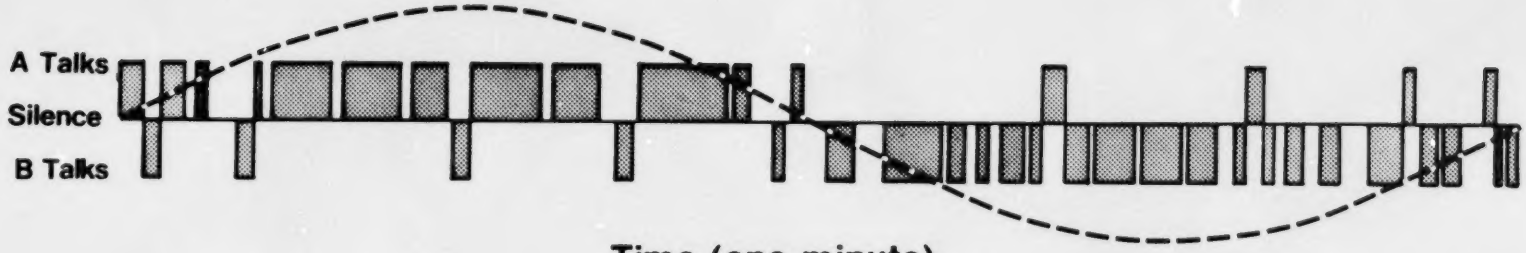
[1]This study was supported in part by National Institute of Mental Health Grant MH20660 and National Science Foundation Grant BNS7617403. The author thanks Jim Purvis and Charles Hopper for their help in collecting the data.

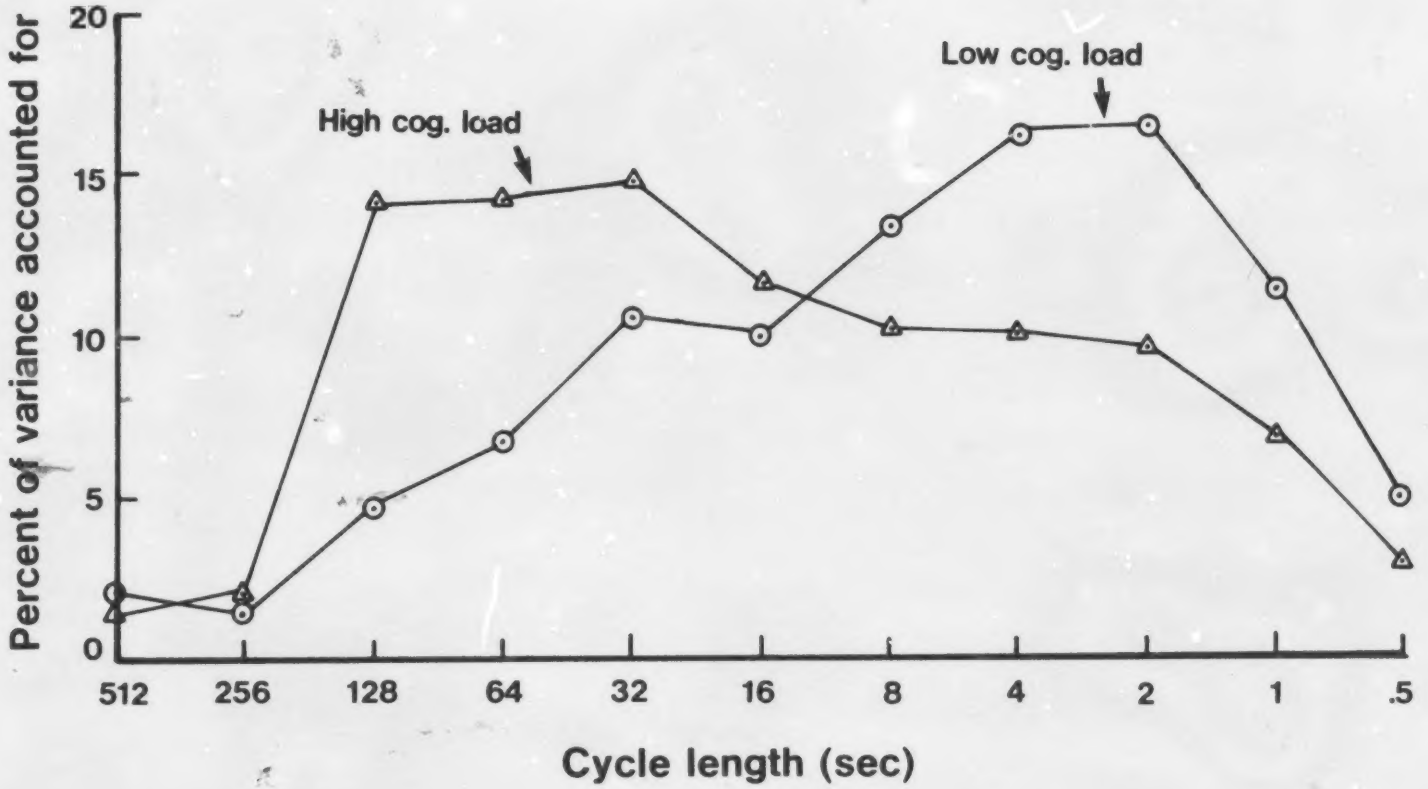
[2]Findings on gaze, along with more traditional analyses of speech and gaze data, are summarized in an unpublished paper by the author, "Indexing the cognitive load of a conversation: speech and gaze."

Figure Captions

Figure 1. Turn taking during a one-minute segment of conversation. A talks more in the first half, and B talks more in the second half. Dashed line shows how individual turns and vocalizations may reflect an underlying "megaturn" cycle.

Figure 2. Power spectra showing how much variance in the turn taking is accounted for by bands of cyclical components of differing lengths. Each curve summarizes mean FFT results for 24 conversations. Short cycles (high frequency components) were more typical of low cognitive load conversations. Long cycles (low frequency components) were more typical of high cognitive load conversations, suggesting that individual turns were aggregated into slow-moving megaturns.


A Talks
Silence
B Talks
Time (one minute)


Percent of variance accounted for
20
15
10
5
0
High cog. load
Low cog. load
512
256
128
64
32
16
8
4
2
1
.5
Cycle length (sec)